3 Concrete Composition and Testing

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CHAPTER THREE: CONCRETE COMPOSITION AND TESTING

In this chapter a description of each component of the concrete and a brief explanation of the function of each of these materials will be discussed. The relationship of one material to another and the proper proportions of each is vitally important to the ultimate quality of the paving concrete.

A common misconception is that cement and concrete are the same material. Cement is only a single component of the concrete, while concrete is composed of cement and various other materials.

A major function of the technician is to test the concrete used in paving. The testing requirements and frequencies for yield, slump, and air content of the concrete for non-QC/QA concrete will be discussed. Flexural strength test beams and the proper sampling techniques will also be explained.

Since concrete testing serves no purpose unless the results can be fully analyzed, accurate documentation of the test results is critical. The proper methods for documenting all test results will be discussed.

MATERIALS

PCCP is normally constructed with paving concrete described in Section **500**. When high early strength pavement is required, additional cement may be added or high early strength cement may be used.

The proportions of materials vary with different types of concrete. Admixtures that affect the air content, water requirements, and the time needed for the concrete to set may be required.

Concrete Mix Design (CMD) proportions are important to know before starting the paving operation. Concrete mix designs are the responsibility of the Contractor, both for QC/QA and non-QC/QA concrete. The Specifications give broad parameters for the Contractor to design an acceptable CMD. The design is reviewed and approved by INDOT. Some Specifications require the Contractor to conduct trial batch demonstrations prior to concrete pours on the contract. Mix designs for QC/QA contracts and concrete using fly ash or other pozzolans are examples of situations requiring trial batches. The Specifications should always be reviewed to determine if a trial batch is required. The PE/PS will have the CMD in the contract files.

Paving concrete is basically composed of the following materials (Figure 3-1):

1) Fine aggregate, size No. 23
2) Coarse aggregate, quality rating class A, Size No. 8
3) Portland cement
4) Water

Additional materials that may be found in paving concrete are:

1) Fly Ash
2) Water-reducing admixture
3) Air-entraining admixture

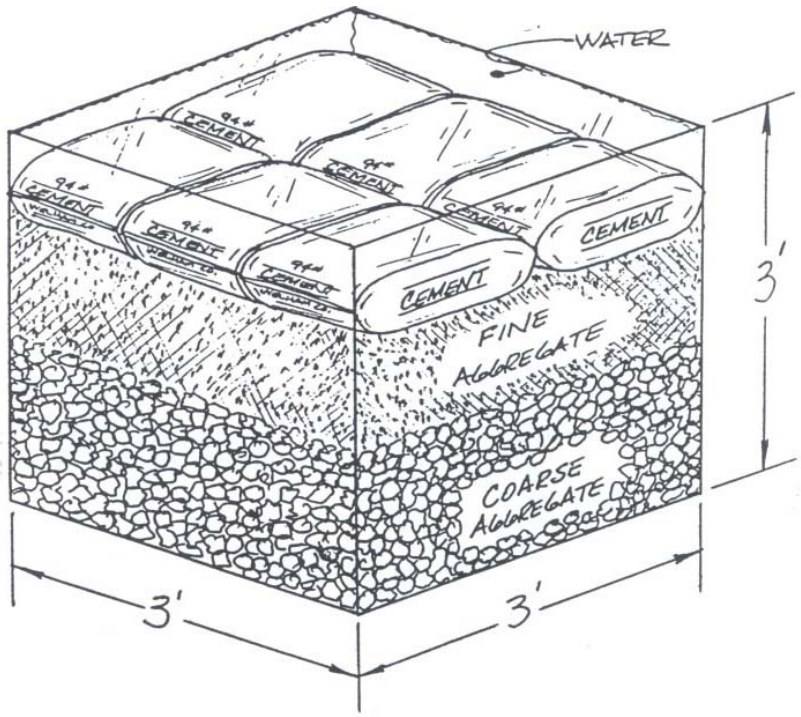

Figure 3-1. Concrete Materials

AGGREGATES

Two sizes of aggregates are used to produce paving concrete. Fine aggregate, size No. 23 natural sand and coarse aggregate size No. 8 crushed limestone, slag, or crushed/uncrushed gravel are used. The proportion of the aggregates is important to the integrity of the concrete and may affect the ultimate strength and the durability of the pavement. The fine aggregate is required to be 35 to 45% (35 to 50% for QC/QA) of the combined total weight of the coarse and fine aggregates (Figurer 3-2).

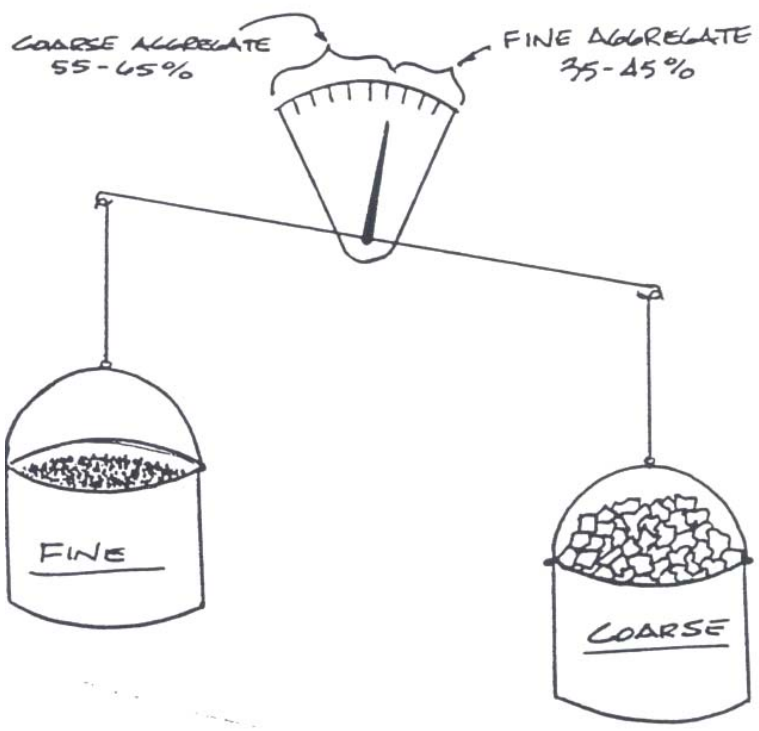

Figure 3-2. FA/CA Proportion

PORTLAND CEMENT

There are many different types of cement available for concrete. Only the following five will be discussed:

1) Portland cement , Type I.
2) Air-entrained Portland cement, Type I-A.
3) Air-entrained Portland-pozzolan cement, Type IP-A
4) High early strength cement, Type III
5) Air-entrained high early strength cement, Type III-A

Under normal conditions Portland cement, Type I will be used in paving concrete. Air-entrained Portland cement, Type I-A, is cement that has

been entrained with air during the manufacturing process and requires less air-entraining agent to be added to obtain the required air content. Portland-pozzolan cement, Type IP is similar to Type I, except that the cement also contains a pozzolan, such as fly ash, to reduce the cost. Air-entrained Portland-pozzolan cement, Type IP-A is similar to Type I-A, except that this cement also contains a pozzolan, such as fly ash , to reduce the cost. When Portland cement, Type IP-A is used, the fly ash specifications are also required. Portland cement, Type III obtains a high early strength. Portland cement, Type III-A is similar except that this cement contains entrained air from the manufacturing process.

Unless otherwise specified, each cubic yard of paving concrete contains 564 lbs (six bags) of cement. A yield test is conducted at the paving site as soon as the first load begins discharging. The results of this test determine the actual amount of cement in each cubic yard of concrete. If the cement content is determined to be high, the aggregate batch weights are required to be increased to lower the total cement content. If the cement content is too low, the aggregate batch weights are decreased to increase the cement content.

FLY ASH

Fly ash is a powdery by-product of coal fired electrical generating plants which has excellent structural properties like cement. The use of fly ash reduces the cost of concrete, but may extend the time needed to achieve the proper strength for opening the pavement to traffic. When fly ash is used, beams (Figure 3-3) are required to be made during each pour. The flexural strength of these beams is the only factor used to determine the opening of the pavement to traffic.

Figure 3-3. Flexural Concrete Beam

The two types of fly ash used in PCCP are Class C and Class F. Class C fly ash has better structural qualities than Class F and is therefore the preferred type of fly ash used. Generally, fly ash may be used between April 1 and October 15. Special permission is required to use fly ash outside of this time frame.

Fly ash may be substituted for up to 20 percent of the cement used in paving concrete. Fly ash will be replaced at 1.25 times the weight of the cement removed. When concrete tests are performed, the amount of fly ash is entered on form IT 652 on the line labeled Pozzolan. The weight of the fly ash is added to the weight of the cement before the yield calculations are determined.

WATER

When the water is added to the cement, the setting and curing process begins. In a central-mix plant this process occurs in the mixing drum, and in a transit mix this process occurs in the truck mixer. Only clean, potable water may be used. Contaminated water may contain materials which are detrimental to the concrete after placement.

After the water is added to the mix, the concrete is required to be placed within 90 minutes, if hauled in truck mixers or truck agitators. If the hauling vehicles have no agitators, this time is reduced to 30 minutes. The actual time the water is added is stamped on the ticket at the concrete plant.

The actual amount of water added at the plant varies from day to day depending upon the moisture contents of the fine and coarse aggregates used. If an overnight rain has caused the stockpiled materials to become wetter than the day before, less water needs to be added at the plant. Materials exposed to hot, dry conditions for several days require more water to be added. The mixture is required to contain no more water than is necessary to produce a concrete that is workable, plastic, and meets the slump requirements; however, the water-cement ratio is required to meet the Specification limits at all times.

TESTING

WATER/CEMENT RATIO

The water/cement ratio is the ratio of the total amount of free water in the aggregates, including all free water in the concrete, to the amount of cement in the concrete (Figure 3-4). For paving concrete, this ratio is required to not exceed 0.487 (0.450 for QC/QA concrete). Also, the variations in one week may not exceed ± 0.030 of the target value established in the CMD. The water/cement ratio is determined at the start of paving, any time the mix proportions or moisture content of the

aggregates change significantly, and once for each 2850 square yards of concrete produced.

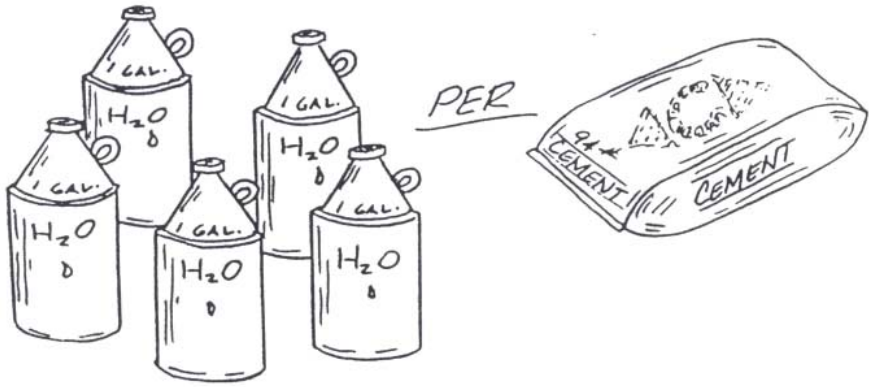

Figure 3-4. Water/Cement Ratio

SLUMP TEST

A slump test (Figure 3-5) in accordance with **AASHTO T 119** is conducted at the paving site. A minimum of one test for every 950 square yards of pavement, with a minimum of one test per day, is required. Additional slump tests may be required at the beginning of the paving operation and at any time during the paving operation when the concrete mix appears to be either excessively wet or dry. All slump test results are reported on form IT 652.

Figure 3-5. Sump Cone

The slump requirements for paving concrete are:

1) Machine placed concrete: No less than 1¼ in. nor more than 3 in., except on superelevated curves where the upper limit may be reduced to 2 in. to prevent slumping during finishing and setting.
2) Hand placed concrete: No less than 2 in. nor more than 4 in.

AIR CONTENT

An air content test is required for each 950 square yards of pavement with a minimum of one per day. **AASHTO T 152** is used for all aggregates except for air cooled blast furnace slag which requires the use of the volumetric air meter in accordance with **AASHTO T 196 (**Figure 3-6). Additional air content tests may be required. When an air content test result is out of the specified range, additional tests are taken on subsequent loads until the problem is corrected. The air content requirement for paving concrete is 6½ ±1½ percent.

Type B Air Meter

Volumetric Air Meter

Figure 3-6. Air Meters

SAMPLING

The method of sampling paving concrete for testing purposes is determined by the method the concrete is delivered to the paver.

When sampling from a revolving drum truck mixer (transit-mix truck) or an agitator truck, the sample may be obtained by directing the chute to a wheelbarrow or to a receptacle on the ground near the testing site. The sample should not be obtained from the chute of the truck. The sample may also be taken after the concrete has been discharged on the grade.

When sampled from the grade, the sample is taken before any machinery comes in contact with the concrete.

When the sample is obtained from a pile on the grade or the ground near the testing site, samples are taken from five different portions of the pile. The sample should not be contaminated with the base material.

Samples for the air content and slump tests should be taken after the discharge of approximately ¼ cubic yard of concrete. Samples for yield tests or beams should be taken at two intervals during the discharge of the middle of the load, but within 15 minutes of each other.

After obtaining the concrete sample, all portions of the concrete should be mixed together with a shovel the minimum amount necessary to obtain proper uniformity.

HIGH EARLY STRENGTH CONCRETE

High early strength concrete may be used when early strength is needed for moving equipment onto the pavement or for opening the pavement to traffic soon after the paving is complete.

High early strength concrete may be made with high early strength cement or by increasing the amount of cement used in the normal mix. Fly ash may be used in high early strength concrete. A CMD is submitted by the Contractor for a workable concrete mixture with a minimum amount of water in accordance with Section **502.04(a)**.

The water-cement ratio for high early strength concrete is required to not exceed 0.42 or 0.45 for Type I and Type III cement, respectfully.

Another option for the Contractor is to use class C concrete, which contains 658 lbs of cement. The use of class C concrete requires the use of water-reducing and retarding admixtures, which are otherwise not permitted.